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# A Synthesis of Agricultural Literacy Research Between 2011 and 2022

Clare Hancock[1]
Carley Morrison[2]
Allyson Moore[3]
Josey Webb[4]
Andra Collins[5]

**Abstract**

*In 2013, Kovar and Ball published a literature review on the agricultural literacy research conducted from 1988 to 2011. As a result of their study, they located 49 articles published in that time frame. Since then, agricultural literacy research has been designated as the number one priority by the American Association of Agricultural Education's (AAAE) National Research Values in 2011, 2016, and 2023; several more studies have been published in response to this call. A recent synthesis of the literature was conducted in order to gain insight on the trajectory of agricultural literacy research within our field from 2011 to 2022. The research team determined that there was an increase in articles published since 2011 and that studies have been expanded to consider new methods and audiences to conduct more robust agricultural literacy research. This increase in agricultural literacy research needs to continue to follow a positive trend, especially since the U.S. population has not demonstrated higher agricultural literacy levels yet (Bradford et al., 2019; Longhurst et al., 2020).*

## Introduction

Agricultural education is a complex discipline; as a field that interacts with and directly affects the general public, it is imperative that the agricultural community effectively communicates information to non-agriculture populations (Clemons et al., 2018; Stofer & Newberry, 2017). The American Association of Agricultural Education's (AAAE) National Research Values have centered on the understanding of agriculture in our society as the number one research priority (Doerfert, 2011; Roberts et al., 2016; AAAE, 2023). In 2023, the National Research Values continued this focus and maintained "advancing public knowledge of AFNR systems" as the first research value listed (AAAE, 2023) since the American public has continued to exhibit low levels of agricultural literacy (Mercier, 2015; Stofer & Newberry, 2017). The American Farm Bureau's (2012) Pillars of Agricultural Literacy indicate that agricultural literacy education

[1] Clare E. Hancock earned her Doctor of Philosophy degree in the Agricultural Education program in the Department of Curriculum and Teaching at Auburn University, Haley Center, Auburn, AL 36849, cet0071@auburn.edu, https://orcid.org/0000-0002-1515-7321
[2] Carley Calico Morrison is an associate professor of Agricultural Education, Leadership, and Communications in the School of Human Sciences at Mississippi State University, 255 Tracy Drive, Mississippi State, MS 39762, carley.c.morrison@msstate.edu, https://orcid.org/0000-0001-6023-0156
[3] Josey Mae Webb earned her Master of Science degree in Agricultural and Extension Education from the School of Human Sciences at Mississippi State University, 255 Tracy Drive, Mississippi State, MS 39762, jmw1552@msstate.edu
[4] Allyson Karyl Moore earned her Master of Science degree in Agricultural and Extension Education from the School of Human Sciences at Mississippi State University, 255 Tracy Drive, Mississippi State, MS 39762, jmw1552@msstate.edu
[5] Andra Collins earned her Doctor of Philosophy degree in the Agricultural Education program in the Department of Curriculum and Teaching at Auburn University, Haley Center, Auburn, AL 36849, auc0001@auburn.edu, https://orcid.org/0009-0007-3454-0119

is needed at all ages, highlighting the importance of the public's need for understanding basic agricultural vocabulary to make informed choices as a consumer. Several studies on the public's perceptions and attitude towards agriculture have revealed that there is a communication gap between the agricultural industry and non-agriculturalists (Lundy et al., 2006; Powers & Roberts, 2022; Settle et al., 2017; Stofer et al., 2023). Most of the public relies on agricultural products and are affected when agricultural issues arise, such as food scarcity, animal diseases, water conservation, among other topics (Dale et al., 2017; McLeod-Morin et al., 2020; Rotz & Fraser, 2015).

In response to AAAE's research values, agricultural education researchers have focused efforts on determining how to overcome lower agricultural literacy levels through various agricultural literacy initiatives (Brune et al., 2020; Vallera & Bodzin, 2016). However, agricultural literacy as a research initiative is not new; concerns surrounding this topic can be traced back to 1988, when the National Research Council determined a growing need for agricultural education to include agricultural literacy as an objective. In this report, an agriculturally literate person was defined as someone who possessed an "understanding of the food and fiber system [which] includes its history and its current economic, social, and environmental significance to all Americans" (National Research Council, 1988, p. 1). These concerns are still echoed today, and current research indicates that agricultural literacy programs responded to the National Research Council's request since 1988 (Anderson et al. 2014; Sandlin & Perez, 2017).

Kovar and Ball's (2013) research examined the literature published on agricultural literacy beginning with the publication of *Understanding Agriculture—New Directions for Education* (National Research Council, 1988) through August 2011. With *Understanding Agriculture* as their parameter, they conducted a synthesis of research based on AAAE conference proceedings and peer-reviewed research journals including *Journal of Agricultural Education*, *Journal of Extension*, and *NACTA Journal*. Focusing on the populations, purposes, and findings of each study, Kovar and Ball (2013) determined that 49 studies on agricultural literacy were conducted between 1988 and 2011. With a little over a decade since their publication, there remains a need to continue synthesizing our literature in order to determine our field's current focus on agricultural literacy research.

Since Kovar and Ball's (2013) review, national action towards increasing agricultural literacy has occurred. In 2013, researchers and practitioners developed a National Agricultural Literacy Logic Model to better communicate a national standard for and definition of agricultural literacy (Spielmaker et al., 2014). Concurrently, Spielmaker and Leising (2014) published the National Agricultural Literacy Outcomes (NALOs) as a response to a "society that has little understanding concerning agricultural production and processing, and how this system meets our basic needs" (p. 2). The NALOs present a structure of which teachers can follow and format their lessons to address this issue at the primary and secondary education levels. The outcomes are split into five themes: Agriculture and the Environment; Plants and Animals for Food, Fiber & Energy; Food, Health, and Lifestyle; Science, Technology, Engineering & Math; Culture, Society, Economy, and Geography. In each theme and grade level, learning objectives are clearly defined; these outcomes are meant to be used with a curriculum and lesson plan database called the National Agricultural Literacy Curriculum Matrix, also developed by Spielmaker in 2014 (National Center for Agricultural Literacy, n.d.).

Additionally, a recurring Agricultural Experiment Station (AES) multistate agricultural literacy research committee has contributed to the growing, published literature on agricultural literacy. Since 2003, these committees (W1006, WERA207, W2006, W3006) have established and followed their own research agenda to help build a more well-rounded understanding of the needs surrounding agricultural literacy. Their research objectives seek to assess agricultural knowledge of population; assess attitudes, perceptions, and motivations of those populations; and evaluate agricultural literacy programs. The current 2020-2024 AES multistate agricultural literacy research committee (W3006) has already produced or collaborated in several publications (Enns, 2023; Judd-Murray, 2023; McFadden et al. 2021) and presented research at

various conferences, such as the North American Colleges and Teachers of Agriculture (NACTA), National AAAE and its regional conferences, Association of Communication Excellence, National Agriculture in the Classroom Conference, and the National Agricultural Communications Symposium.

Within the field of agricultural education, research has indicated that the U.S. population is still not agriculturally literate (Dale et al., 2017; Stofer & Newberry, 2017). However, agricultural literacy research and initiatives continue to emerge from our discipline, and there are continued efforts being made towards a more agriculturally literate society. This article aims to identify and analyze those recent efforts.

**Purpose and Research Questions**

The purpose of this study is to replicate and expand upon Kovar and Ball's (2013) article, which presented a synthesis of agricultural literacy research from 1988 to 2011. Starting after Kovar and Ball's article, our synthesis includes literature from 2011 to 2022, providing a recent review and insight on the trajectory of agricultural literacy research within our field. As such, our research questions are similar to those of Kovar and Ball's:

1. What studies were conducted in agricultural education regarding agricultural literacy since Kovar & Ball (2013)?
2. What populations were targeted in agricultural literacy research?
3. What was the purpose of the agricultural literacy research?
4. What recommendations were suggested based on a summary of the agricultural literacy research?

## Methods

This study's methods follow Kovar and Ball's (2013) synthesis of agricultural literacy research. Conducting a synthesis by reviewing past research and building themes from our literature is insightful to our field (Cooper, 2010). In this way, previous literature provides data that can be assessed and combined to highlight common trends, providing a tangible understanding of the direction of research in our field. Our review of the agricultural literacy research from the past decade was conducted through collection, coding, triangulation of data, and recoding (Denzin, 1970).

Similar to Kovar and Ball (2013), search inclusion and criteria were determined first; databases such as journal websites and ERIC were the main library systems used. Since AAAE conferences accept and present research that follows the National Research Agenda, and Kovar and Ball included AAAE conference proceedings within their search, our study includes this database as well. Keywords including "agricult* literacy" and "agricult* education" were generated to locate articles and add them to an Excel spreadsheet to later be coded. Diverging from Kovar and Ball, other versions of agricultural literacy, such as scientific literacy and media literacy were included as well but only if they centered on agriculture. Publication of articles had to be between August 2011 (when Kovar and Ball stopped collecting articles) and May 2022 (National AAAE Conference). As a result of the search, 62 individual articles were located through the *Journal of Agricultural Education*, *Journal of Extension*, *Journal of Applied Communication*, *NACTA Journal*, or AAAE research conference proceedings. All regional conferences and the national conference were included, but only the paper proceedings of each conference were considered.

A coding matrix was sent out to three additional researchers. Individually, we read the 62 selected articles and determined the 1) target population, 2) purpose of study, and 3) study recommendations for each. Code groups mirrored Kovar and Ball's (2013) coding matrix:

1. Target population: a) *teachers*, b) *students*, c) *non-educator adults*, and d) *other*
2. Purpose of study: a) *assessing agricultural literacy*, b) *testing a program*, c) *developing a framework or guide*, and d) *other*

3. Recommendations: a) *assessing agricultural literacy*, b) *testing the effectiveness of a program*, and d) *other*

After members identified coding for each section, the results were compiled, compared, and examined. Any coding that resulted in *other* was re-evaluated; as a result, new categories emerged, and articles were then regrouped according to the new coding system.

## Results

### Research Question 1: What studies were conducted in agricultural education regarding agricultural literacy?

Since Kovar and Ball's (2013) article, 62 articles ($n = 62$) were located within five databases. While Kovar and Ball located three other sources that included agricultural literacy research, no miscellaneous sources were found in this study. Instead, the *Journal of Applied Communications* was added to the overall list, as several agricultural literacy research studies were found within that source. The *Journal of Applied Communications* was not previously identified as a contributing source in Kovar and Ball's study.

Every year, from August 2011 to May 2022, research on agricultural literacy was published (Table 1). Not all of 2011 and 2022 were included in this search, therefore lower numbers of publications are reported in these timeframes. However, there are entire years that contain 1-3 publications, such as 2012, 2013, and 2015. Notably, 2016 contains the highest number of publications at 12, with 2019 close behind at ten publications. AAAE regional and national conferences produced the highest number of publications at 50.00% ($n = 31$), and the *Journal of Agricultural Education* was the highest-producing journal with 11 articles.

**Table 1**

*Published Agricultural Literacy Research Locations, 2011-2022 (n=62)*

| Year | JAE | NACTA | JOE | JAC | AAAE | Total |
|---|---|---|---|---|---|---|
| 2011 | 1 | 0 | 0 | 0 | 0 | 1 |
| 2012 | 0 | 0 | 0 | 0 | 1 | 1 |
| 2013 | 0 | 0 | 2 | 0 | 0 | 2 |
| 2014 | 1 | 0 | 0 | 2 | 2 | 5 |
| 2015 | 0 | 0 | 2 | 1 | 0 | 3 |
| 2016 | 2 | 1 | 1 | 3 | 5 | 12 |
| 2017 | 2 | 1 | 1 | 0 | 2 | 6 |
| 2018 | 1 | 0 | 3 | 0 | 5 | 9 |
| 2019 | 1 | 1 | 0 | 1 | 7 | 10 |
| 2020 | 3 | 0 | 0 | 0 | 2 | 5 |
| 2021 | 0 | 1 | 0 | 0 | 4 | 5 |
| 2022 | 0 | 0 | 0 | 0 | 3 | 3 |
| Total | 11 | 4 | 9 | 7 | 31 | 62 |

### Research Question 2: What populations were targeted in agricultural literacy research?

Originally, the themes identified within Kovar and Ball's (2013) study were used as the basis to determine the target populations (*teachers*, *students*, *non-educator adults*, and *other*). When new themes emerged, the themes were updated to reflect recent research trends. For this reason, *Extension professionals*, *agricultural stakeholders*, and *non-population* categories were added (Table 2). Extension professionals

were categorized under teachers, as they are a major part of agricultural education, and preservice teachers were included in the college students category, as they are still students.

Students were the highest identified target population, covering 51.61% of the total target populations ($n$ = 32). Of these students, elementary ($n$ = 7), high school ($n$ = 9), and college ($n$ = 11) were the most prevalent. Teachers as a target population followed at 19.35% ($n$ = 12), and K-12 teachers were found to be the highest identified descriptor within that population. Non-educator adults and other were lower in identification, making up 17.74% ($n$ = 11) and 11.29% ($n$ = 7) of the total target population. Seven articles were found to have non-populations as their target (literature reviews, curriculum studies, messaging platforms, etc.).

**Table 2**

*Participant Groups Included in Agricultural Literacy Research, 2011-2022 (n = 62)*

| Target Population | *f* | *%* |
|---|---|---|
| Teachers | | |
| Elementary | 2 | 3.23 |
| Middle School | 1 | 1.61 |
| High School | 1 | 1.61 |
| K-12 | 6 | 9.68 |
| Extension Professionals | 2 | 3.23 |
| **Total** | **12** | **19.35** |
| Students | | |
| Elementary | 7 | 11.29 |
| Middle School | 2 | 3.23 |
| High School | 9 | 14.52 |
| K-12* | 3 | 4.84 |
| College | 11 | 17.74 |
| **Total** | **32** | **51.61** |
| Non-educator adults | | |
| Community Members | 8 | 12.90 |
| Agricultural Stakeholders | 3 | 4.84 |
| **Total** | **11** | **17.74** |
| Other | | |
| Non-population | 7 | 11.29 |
| **Total** | **7** | **11.29** |
| Overall Total | 62 | 100 |

* K-12 was included as a category due to some articles not specifying age or grade level

**Research Question 3: What was the purpose of the agricultural literacy research?**

The themes *testing a program*, *assessing agricultural literacy*, and *developing a guide or framework* were reused from the Kovar and Ball (2013) article as our initial themes of research. However, *developing a guide or framework* was changed to *developing an instrument* to include studies that produced guides, frameworks, models, matrices, assessments, and instruments. The coding team found other themes, which included *examining perspectives*, *conducting discipline introspection*, and *evaluating through content analysis* (Table 3). *Testing a program* was the highest identified study purpose, as 25 articles shared

this goal. The lowest identified purposes were *developing an instrument* (*n* = 3) and *evaluating through content analysis* (*n* = 3).

**Table 3**

*Purpose of Agricultural Literacy Research, 2011-2022 (n = 62)*

| Purpose | *f* | *%* |
|---|---|---|
| Testing a program | 25 | 40.32 |
| Examining perspectives | 15 | 24.19 |
| Assessing agricultural literacy | 12 | 19.35 |
| Conducting discipline introspection | 4 | 6.45 |
| Developing an instrument | 3 | 4.84 |
| Evaluating through content analysis | 3 | 4.84 |
| Total | 62 | 100 |

**Research Question 4: What recommendations were suggested based on a summary of the agricultural literacy research?**

Kovar and Ball (2013) identified the same coding themes for research question three and four, using 1) *testing a program*, 2) *assessing agricultural literacy*, and 3) *developing a guide or framework* to categorize their articles' research purposes and recommendations. Again, for this research question, we used these same themes for the first round of coding and then re-categorized the findings based on new themes that emerged. For this study, new themes included *developing or revising curriculum*, *conducting further research*, *developing or revising professional development*, *testing an instrument*, and *adjusting or reframing audience messaging strategies*. As a team, we found that there were too many outliers to stay within the previously determined themes. For example, the theme c*onducting further research* was created for research that either did not have a clear recommendation, suggested multiple avenues, or specified to replicate the study again.

The top three most identified research recommendations were *developing or revising curriculum* (*n* = 12), *testing a program* (*n* = 12), and *conducting further research* (*n* = 10). At 4.84%, *developing an instrument* (*n* = 3) was the least identified recommendation (Table 4).

**Table 4**

*Recommendations of Agricultural Literacy Research, 2011-2022 (n = 62)*

| Purpose | *f* | *%* |
|---|---|---|
| Developing or revising curriculum | 12 | 19.35 |
| Testing a program | 12 | 19.35 |
| Conducting further research | 10 | 16.13 |
| Developing or revising professional development | 8 | 12.90 |
| Testing an instrument | 8 | 12.90 |
| Adjusting or reframing audience messaging strategies | 5 | 8.06 |
| Assessing agricultural literacy | 4 | 6.45 |
| Developing an instrument | 3 | 4.84 |
| Total | 62 | 100 |

## Discussion

The field of agricultural education has greatly expanded the number of studies on agricultural literacy over the past decade. In Kovar and Ball's (2013) study, 49 articles were identified from 1988 to 2011. As a result of this study, it was determined that 62 articles have since then been published from 2011 to 2022. Comparatively, the agricultural literacy research conducted increased from 2.13 to 5.64 articles a year, which is an increase of 164.79%.

Additionally, Kovar and Ball (2013) found that the highest number of publications was in 1994 and 1999, at four publications each. Comparatively, the highest number of publications we found was in 2016 ($n$ = 12) and 2017 ($n$ = 10). These findings demonstrate that a greater emphasis has been placed on agricultural literacy in the past decade, continuing the positive trend found by Kovar and Ball. The increase in 2017 may also be attributed to the emphasis placed on agricultural literacy as the first research priority in the National Research Agenda released in 2016 (Enns et al., 2016).

Furthermore, AAAE conferences continue to be the highest contributing source of agricultural literacy research, as they made up 36.73% ($n$ = 18) of Kovar and Ball's findings and 50.00% ($n$ = 31) of our findings. Academic conferences serve as a space for having robust conversations and strengthening burgeoning studies. This finding is particularly of note to our field, as it shows that we frequently and consistently engage in discussion of this topic at the regional and national level every year. Moreover, the *Journal of Agricultural Education,* published by AAAE, produced the largest number of agricultural literacy publications. For example, Kovar and Ball found that the *Journal of Agricultural Education* produced 17 articles over 20 years, and our study located 11 articles over ten years. Thus, the *Journal of Agricultural* Education has continued to be the main host for agricultural literacy publications.

Within our study, 32 articles (51.61%) indicated a target population of students. Within this population, five themes emerged: 1) *elementary*, 2) *middle school*, 3) *high school*, 4) *K-12*, and 5) *college*. While Kovar and Ball (2013) found elementary students to be the primary target population during their timeframe of research published, we found that high school and college students were more frequently designated. For example, Baker and Eck (2019) conducted a study that assessed high school students' knowledge and perceptions of GMOs. As a result, it was determined that the students were not scientifically or agriculturally literate in relation to their understanding of GMOs. Thus, they recommended that school-based agricultural education (SBAE) instructors engage in more focused professional development to better address this topic in their courses. Other examples of research that identified high school students as their target population typically assessed agricultural literacy, tested an agricultural literacy program, or reviewed curriculum (Bradford et al. 2016; Calico et al. 2014).

We also found that almost half of the articles addressing college students ($n$ = 10) specifically focused on pre-service teachers ($n$ = 4). Retention of teachers is a common research topic within agricultural education (Guffey & Young, 2020; Moser & McKim, 2020), and supporting the next generation of teachers is a recognized need within our field. For example, Tummons et al. (2020) evaluated the newly offered preservice professional development at the Curriculum for Agricultural Science Education (CASE) institute; the study particularly focused on the participants' experiences with the use of literacy strategies in the agricultural classroom. Tummons et al. found that the preservice teachers in attendance were generally unaware of or were newly introduced to the connection between utilizing literacy strategies in the classroom and increasing agricultural content knowledge. By contextualizing literacy in the agricultural classroom, the CASE institute helped preservice teachers become more conscious of their future role in agricultural education, which included increasing agricultural literacy. In other words, as a result of the program, these teachers realized how they could affect their students' agricultural literacy by using literacy strategies.

Additionally, Lemley & Hart (2019) used the Disciplinary Literacy Project to further bolster preservice teachers' literacy practices in the agricultural classroom. While the study was guided by Moje's (2015) 4E's Heuristic of Disciplinary Literacy Instruction which does not specifically focus on agricultural literacy, the project was used in an agricultural context with future agricultural teachers as the participants. Preservice teachers were asked to consider what disciplinary literacy looks like in agriculture and how they can integrate literacy-specific practices into their classroom to enhance their students' understanding of agriculture as a discipline. In particular, participants were able to identify scaffolding techniques to help their students better grasp agricultural terms, concepts, and information, which will in turn increase their students' agricultural literacy. In fact, by the end of the study, the research team noted that their participants were able to recognize where they could integrate the Pillars of Agricultural Literacy into their instruction and planning (American Farm Bureau, 2012).

These studies, among others, demonstrated that preservice teachers are a population that could benefit from more instruction on how to integrate agricultural literacy strategies into their teaching practice, particularly before they begin their full-time teaching profession. Thus, it is important to determine the preparedness and perceptions of preservice teachers towards agricultural literacy, as their understanding of agricultural literacy can affect their own effectiveness as future teachers (Clemons et al., 2018).

Since 2011, studies have slightly adjusted their range regarding purposes for agricultural literacy research. While we did start with Kovar and Ball's (2013) original three themes (*testing a program*, *assessing agricultural literacy*, and *developing a guide or framework*), we ended up adding three more (*examining perspectives*, *conducting discipline introspection*, and *evaluating through content analysis*). These added themes indicate the evolution of a wider focus in agricultural literacy research, moving beyond just an assessment or program testing approach. However, *testing a program* and *assessing agricultural literacy* still remain among the majority in the purposes of the studies identified. With *testing a program* accounting for 40.32% ($n$ = 25) and *assessing agricultural literacy* making up 19.35% ($n$ = 12), it is clear that agricultural literacy research is primarily based in these two objectives.

Nonetheless, the only other theme that was identified the most, more than *assessing agricultural literacy*, was *examining perspectives* at 24.19% ($n$ = 15). Several articles expressed interest in investigating attitudes of teachers, community members, and students towards various agricultural literacy initiatives or existing situations. For example, Pennisi et al. (2018) sought to better understand community support towards an agricultural literacy project that included an environment education center and demonstration farm. Similarly, Anderson-McCoon et al. (2016) surveyed participants' experiences with livestock exhibits at a state fair in order to determine the overall attitude towards animal agriculture. Both of these examples show a research objective that neither assesses the agricultural literacy of a population nor the success of an agricultural literacy program. Instead, this type of purpose informs our field of potential avenues for further research, studies that could then assess literacy or implement a program.

*Developing or revising curriculum* ($n$ = 12) shared the highest identified recommendation theme with *testing a program* ($n$ = 12). Because of the number of studies that particularly focused on curriculum design or reform, our team recognized the need to code them in their own category. Considering students and teachers were the target population for the majority of the articles found, the recommendation to change curriculum makes sense. In Vallera & Bodzin's (2016) study, a content analysis was performed on several in-use elementary science textbooks and curriculum to determine if and how agriculture was taught to students. Their findings suggested that while agricultural concepts were taught, the curriculum did not appropriately integrate opportunities for increased agricultural literacy. Their recommendation was to redesign the curriculum with agricultural literacy in mind. As students have continued to be the primary focus in teaching agricultural literacy (Kovar & Ball, 2013), teachers need to be able to rely on curricula that will effectively cultivate and strengthen agricultural literacy skills.

The use of curricula in the classroom is very similar to the design and use of agricultural literacy programs. Both provide a medium through which participants can be introduced to concepts in agriculture, increasing their agricultural literacy. We identified several studies (Anderson et al., 2014; Luckey et al., 2013; Rodriquez et al., 2015) that tested the success of an agricultural literacy program and then recommended further testing or the testing of similar programs. For instance, Anderson et al. (2014) captured and traced the attitudes of K-12 teachers during their experience at a Summer Agricultural Institute. Through the collection of this data, Anderson et al. were able to track changes in perceptions and determine that the program was indeed successful. However, they still suggested ways to further test the program and fully explore every avenue of potential improvements.

**Recommendations**

With even more agricultural literacy research produced in the past decade after Kovar and Ball (2013), we recommend that agricultural literacy research continues to be conducted and published in the decades to come. However, in this study and during the years we looked at, our search terms did not lead to any publications outside of the agricultural education field. In an effort to educate non-agricultural fields about agricultural literacy, we also recommend extending agricultural literacy research and terminology in publications to other disciplines. Additionally, the paper presentations found within the proceedings of AAAE conferences did not seem to develop into articles published in our field's journals. We recommend that studies presented at AAAE conferences continue to pursue publication in our journals or in other disciplines' journals.

Further confirming Kovar and Ball's (2013) findings on population, we found that students and teachers still accounted for the majority of the target population at a combined 70.97%, within 44 out of the 62 articles. However, more target populations were identified within this study, showing that agricultural literacy research has expanded its focus to other target populations besides teachers and students, such as agricultural stakeholders and Extension professionals. We recommend researchers continue to broaden their target populations in order to account for the various and diverse places where agricultural literacy can be assessed.

While testing programs and assessing agricultural literacy are still preferred purposes in agricultural literacy research, this study discovered that new research purposes have emerged over the last decade. Examining the perspectives of teachers and students in order to better understand how to conduct agricultural research is a new trend. Conducting content analyses of agricultural curricula, videos, messages, and other media-based mediums for agricultural literacy is also another new research trend. We recommend a continuation of these new lines of inquiry, as examining these elements will help strengthen agricultural literacy initiatives overall. In the same vein, the recommendations identified from published studies mostly suggested developing/revising curriculum or testing a program. Therefore, we also recommend further testing of agricultural literacy programs and more research on the perspectives of populations in order to make sure that the programs will reach their intended audience.

Ultimately, our field has been actively assessing and promoting agricultural literacy in recent years. The research conducted has evolved since Kovar and Ball's (2013) study, and we expect it to continue to flourish and evolve as more time passes. The emphasis on agricultural literacy needs to remain a critical concern for our field, as populations continue to engage with agriculture systems without fully recognizing it.

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